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MASS AND HEAT RECOVERY SYSTEM

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ABSTRACT :

In the last few years heat recovery was under spot . and in air conditioning fields usually we use heat recovery by different types of heat exchangers .

The heat exchanging between the exhaust air from the building with the fresh air to the building (air to air heat exchanger) .

In my papers i use (water to air heat exchanger) as a heat recovery . and I use the water as a mass recovery .

The source of mass and heat recovery is the condensate water which we were dispose and connect it to the drain lines .

THE BENEFIT OF THIS SYSTEM ARE :

1) Using the heat energy from the condensate water to reduce the fresh air temper . In cooling and air conditioning fields . Via heat exchangers (ENERGY SAVING) .

2) Using the dispose water as a mass flow in different purposes like irrigation systems, W.C. flush thanks systems, etc. (MASS SAVING) .

3) Saving some of electric power consumption and then less operation costs due to item (1) .

4) Reduce the required daily water for irrigation, or flush thanks and then less Operating Costs due to item (2).

MASS AND HEAT RECOVER SYSTEM (MHRS)

A. INTRODUCTION :

In the last few years heat recovery was under researches spot. Because of at the end of its application it's reduce the operation cost for the building . we use heat recovery in air conditioning field by different types of heat exchangers between the exhaust air from the building and the fresh air to the building (air - to air heat exchanger).

In this paper we use (water - to air heat exchanger) as a heat recovery and we use the water as a mass recovery .

B. MHRS DESCRIPTION :

Until now we still dispose the condensate water by free discharge or connect it to the drain network that water carrying heat energy . And in the same time condensate water we can use it again as a mass flow in different uses.

Figure (1) showing the mass and heat recovery system (MHRS) layout . This layout can divided to four (4) sections :

1. Mass and heat collection (MHC) .
2. Mass and heat storage unit (MHSU) .
3. Heat recovery unit (HRU) .
4. Mass recovery unit (MRU) .

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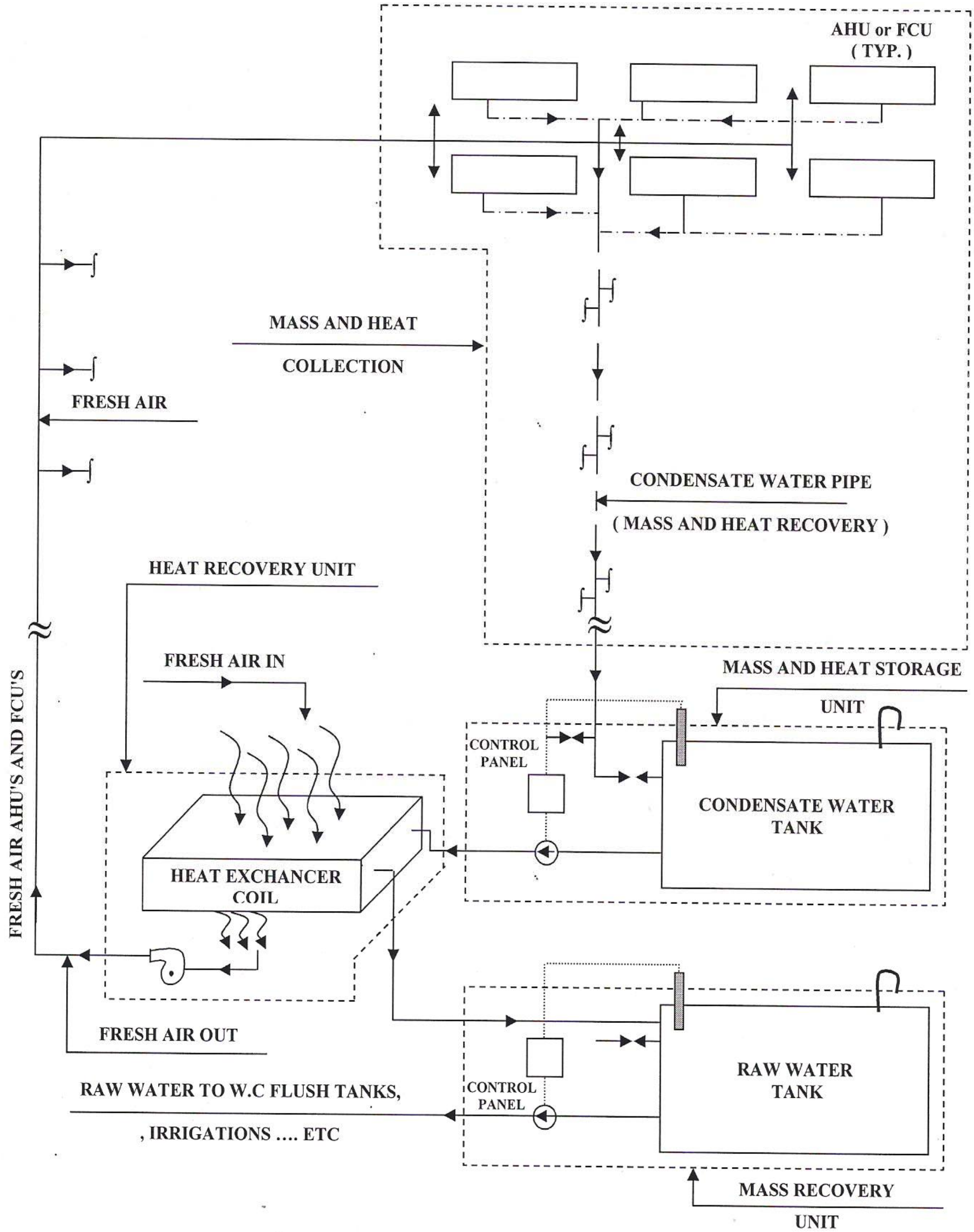

FIGURE -1 : *Mass And Heat Recovery System*.

For individual description as following :

1) **Mass and heat collection (MHC) :**

When the water or refrigerant in the coil is at a lower temperature than the dew point of the entering air, moisture will be condensate out of the air .

As indicated in figure (2) . Collection of the condensate water from all air handling units (AHU'S) and fan coil units (FCU'S) by gravity through insulated UPVC pipes network to one main line . Which will go to mass and heat storage unit at the lower level of AHU'S & FCU'S installation . Taking in consideration to extend the highest points of the piping network as a vent . The components of this section are : (The existing AHU'S & FCU'S - UPVC pipes and its fittings & thermal insulation) .

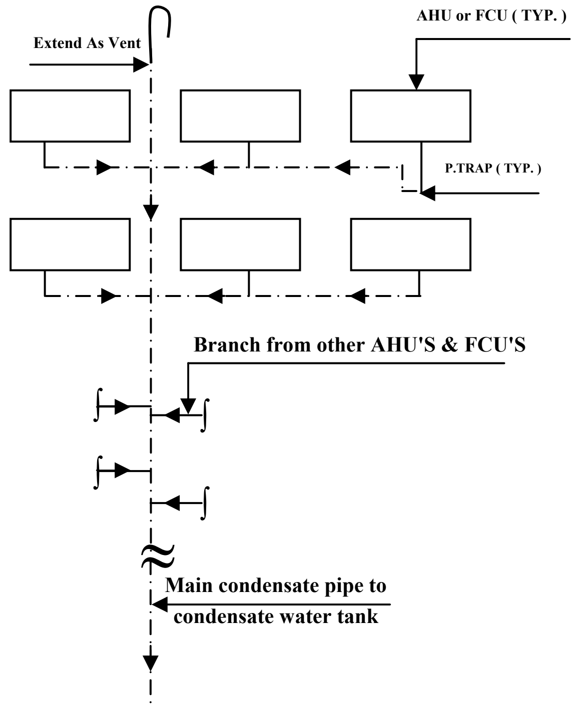

FIGURE - 2 : *Mass And Heat Collection*

2) **Mass and heat storage unit (MHSU) :**

As indicated in figure (3) the main condensate water pipe from (MHC) will discharge in the condensate water tank which is fitted with float switches for pumps dry running protection and operation control . The pumps will suck the condensate water and discharge to (HRU) . Provision for by pass line is required to use it in case of maintenance . By pass line will connect to raw water tank .

The amount of condensate water flow can be determine by calculating the total condensate water from AHU'S & FCU'S for one hour . And it can be the same for (HRU) pump capacity . It will be more advanced if we use variable speed pump link with the condensate water flow . The components of this section are (condensate water tank – pumps – control panels with sensors , switches , etc. - piping & fittings) .

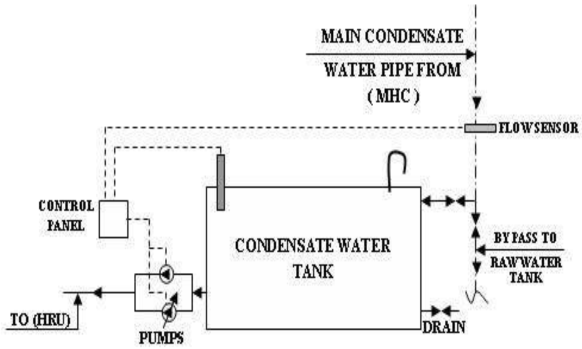

FIGURE – 3 : *Mass And Heat Storage Unit .*

3) **Heat recovery unit (HRU) :**

In figure (4) the discharged condensate water from (MHSU) to (water to air heat exchanger) to reduce the fresh air temperature which will supply by blower to AHU'S & FCU'S . The outlet water will go to the existing building raw water tank . This section can be supplied as a packaged unit from the manufacturer.

The section components are (Coil – Blower – Casing) coil and blower design as per building condition.

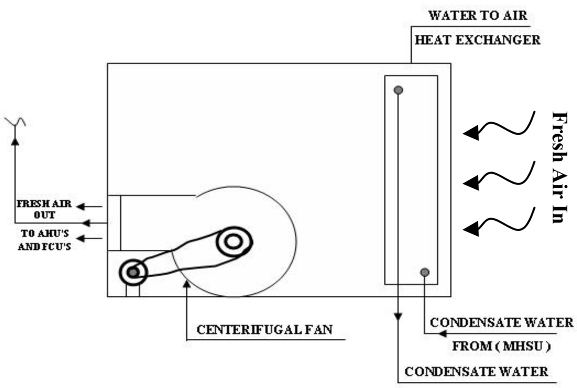

FIGURE – 4 : *Heat Recovery Unit*

4) **Mass recover unit (MRU) :**

In figure (5) the condensate water from (HRU) will feed raw water tank and it will reduce the municipality

consumption . We recover the condensate water and use it in difft. Purposes .

There are tow sets of pumps discharge the water to W. C. flush tanks, irrigation system , … etc.

The section components are (raw water tanks – pumps – control panels with sensors , switches, … etc. – piping & fittings) .

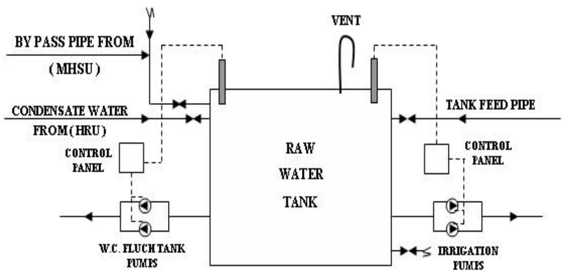

FIGURE – 5 : *Mass Recovery Unit*.

From the above mentioned sections we notice that sections No. 1 & 4 are available and existing in any project or building . Only some additional pipe works . Sections No. 2 & 3 are new and required for mass and heat recovery system .

Also there is flexibility in the system . we can use mass recovery only by using the flow rate of condensate water in irrigation or W.C. flush tank systems . and it is easy to install in the existing projects since the initial cost is low .

C. SAMPLE PROJECTS :

1) Executive Projects :

I have installed condensate water pipe network for one of my previous projects (800 R.T. Cooling Capacity) as a mass recovery on 2000 .

It was transportation center (in Riyadh K.S.A) consist of three (3) buildings . The HVAC system installed in those building is as follows :

a. Air cooled chiller (CH) 4 NOS. each capacity 210 R.T. .

b. Air handling unit (AHU) 16 NOS. different capacities .

c. Fan coil unit (FCU) 55 NOS. different capacities.

The design conditions were :

- **Entering air conditions :**

80 °F DB , 68 °F WB , 62.1 °F DP , 0.012 Ib moisture/Ib dry air (HR) & 13.87 F^3/Ib dry air (v) .

- **Leaving air conditions :**

60 °F DB , 50.2 °F WB , 41.5 °F DP , 0.0055 Ib moisture/Ib dry air (HR) & 13.21 F^3/Ib dry air (v) .

Where : DB = Dry bulb temperature .
WB = Wet bulb temperature .
DP = Dew point temperature .
HR T Humidity ratio .
V = Specific volume .

Condensate Water = Air flow F^3/m × [HR (entering) – HR (leaving)] Ib moisture / Ib dry air × $^1/_V$ Ib dry air / F^3 .

= 320000 × (0.012 – 0.0055) × $^1/_{13.87}$
= 149.95 Ib/Min .
T 68 kg/Min T 68 Liter/M
T 17.99 GPM

If we consider 8 hours daily working with 70% diversity factor .

Total mass recovery = (Water flow/Day)

= 68 × 8 × 60 × 0.7
= 22.8 m^3 / day

We have now 22.8 m^3 water per day we connect it to building raw water tank which feed the irrigation system and W.C. flush tanks .

2) Calculated sample project :

we will assume 1000 refrigerant ton cooling capacity project .

- **Location :**

Kuwait, at the Arabic gulf coast .

Ambient Conditions :

DB = 119.7 °F & WB = 89.6 °F from (ASHRAE) fundamentals handbook 2005 (Climatic Design Data Tables) .

Return Air Condition :

DB = 80 °F, WB = 68 °F, DP = 62,1 °F HR = 0.012 Ib . Moisture / Ib Dry air.

Considering 400 CFM/R . Ton and 10% fresh air .

Total flow = 400 × 1000 = 400000 CFM .

Fresh air = 40000 CFM

Out door air (Fresh air) at 119.7 °F DB and 89.6 °F WB is to be mixed with room air (Return air) at 80 °F DB and 68 °F WB the final mixture is to consist of 0.1 fresh air and 0.9 return air .

Mixing (DB) Temp. = 0.1 × 119.7 + 0.9 × 80 = 83.97 °F .

From psychometric chart :

Entering Mixing (WB) = 70.7 °F & DP = 65 °F .

Entering Mixing (HR) = 0.0131 Ib Moisture / Ib dry air .

Entering Mixing (SV) = 13.99 F^3/Ib dry air .

Leaving Conditions :

DB = 60 °F, WB = 50,2 °F , HR = 0.0055 Ib Moisture / Ib dry air .

▪ Mass Recovery Calculation :

Condensate water flow :

Air flow × [HR (ent.) – HR (lea.)] × $^1/_{SV}$
= 400000 (0.0131 – 0.005) × $^1/_{13.99}$
= 231.59 Ib / min
= 105.27 kg/min
T 105.3 liters/min
T 27.85 GPM

If we consider 8 hours daily working with 85% diversity .

▪ Then :

The total mass recovery =

(Water flow / day)
= 105.3 × 8 × 60 × 0.85
= 42962 liters / day
= 43 m^3/day

This amount of water relate to some conditions :

1. **Outdoor humidity (Increase with higher humidity) .**
2. **Fresh air (Increase with more fresh air) .**
3. **Operation condition (Increase with more room latent heat gain) .**
4. **Diversity and load demand factors (Decrease with less than 85%) .**

▪ Heat Recovery Calculation :

The heat exchanger pumps will be capable to discharge the condensate water flow rate .

Then the pump capacity =
= 27.85 × 0.85 (Diversity factor)
= 23.67 GPM

Since the dew point temperature for entering air is 65 °F . Allow 3 °F more for heat gain . Then the condensate water temperature is 68 °F .

As shown in figure (6) we have cooling media (Condensate water) 23.67 GPM & 68 °F .

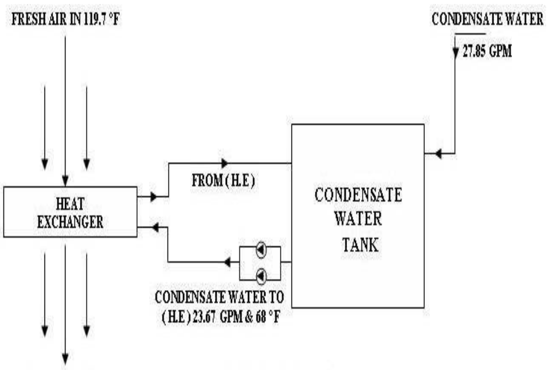

FIGURE - 6 : *Cooling Media.*

And the manufacturer will design heat exchanger (Heat recovery) to let the fresh air absorb heat from condensate water . With this condition

(fresh air in 119.7 °F D.B – fresh air out 90 °F D.B) .

The total heat absorbed from the condensate water can be determine from this equation :

$$
\begin{aligned}
Q\ (\text{Btu/hr}) &= 500 \times GPM \times \Delta T \\
&= 500 \times 23.67 \times (84 - 68) \\
&= 189360\ \text{Btu/hr} \\
&= 15.78\ \text{R.T/hr}\ (\text{heat recovery})
\end{aligned}
$$

It mean we can give 15.78 R.T/hr to the fresh air .

$$
\begin{aligned}
\text{For 8 Hrs/day} &= 15.78 \times 8 \\
&= 126.24\ \text{R.T/day}
\end{aligned}
$$

The flow amount of fresh air depend on the design of heat exchanger and fresh air in & out temperatures .

Now we have in 1000 R.T. cooling load project .

1- **Mass recovery as a water:**
   $= 43\ m^3/day$
2- **Heat recovery = 126.24 R.T/day**
   This heat load 126.24 R.T / day can let us save electric power consumption which we were locking to produce this amount of heat load . As following .
   Electric power saving =
   $= 126.24 \times 1.5$ **Kw**
   $= 189.36$ **Kw/day .**

D. Prefer Location :

when the water or refrigerant in the coil is at a lower temperature than the dew point temperature of the entering air , moisture will be condensate out of air .

we know that . The dew point temperature increase with the higher (Relative humidity, wet bulb temperature) there fore water condensation will start early and more .

The areas which we can obtain the best results are in the humidity locations.

Specially in Arab gulf countries and similar countries .

(There are humidity, less natural soft water and hot weather) .

E. Benefit :

The installation of heat and mass recovery system give us the following advantage :

a) **Using the heat energy from the condensate water to reduce the fresh air temperature in cooling and air conditioning fields via heat exchangers (Energy saving).**

b) **Using the condensate water as a mass flow in different purposes like irrigation systems , W.C. flush tanks systems & …… Etc .**

c) **Saving some of electric power consumption and then less operating costs due to item (a) .**

d) **Reduce the required daily water need for irrigation & W.C. flush tanks and then less operating costs due to item (b) .**

F. Conclusion & Aim :

Using some of mass and energy which were dispose to the waste .

We are locking to install the mass and heat recovery system in the suitable projects . Even if it is existing, this system will achieve sustainable energy saving and less operating cost .

G. References :

- **ASHRAE Hand Books .**
- **2005 Fundamentals .**
- **2004 HVAC Systems and Equipment .**